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BOX 272
CALABASAS CA
91302

Popular Computing

VOL 2 NO 4
APR 74

FIGURE K

11	1	4, 12	3, 7, 8	5, 10	6, 9	2	
2	7, 8	6, 10	9	1	4, 12	5, 11	3
6, 10	5, 9, 12	2	4, 11	3		1	7, 8
1, 4		3		7	5, 8, 11	10, 12	2, 6, 9
3, 8	10	1, 5	6	9, 12	2	7	4, 11
5, 7, 12	6, 11	8	2	4		3, 9	1, 10
9	2, 3	7	5	8, 11	1, 10	4, 6	12
	4	9, 11	1, 10, 12	2, 6	3, 7	8	5

8 Queens

PROBLEM 42

PC13-2

8 Queens

The 8 queens problem requires placing 8 chess queens on a board in such a way that none of them is under attack from any of the others. There are just 12 solutions to that problem, and all of them are shown in Figure K. For example, all the circles labelled 7, taken in order from rows 1 to 8, lie in columns 4, 2, 8, 5, 7, 1, 3, and 6, and form one of the 12 solutions.

The array in Figure M also shows the 12 solutions. They are given in column A in such a way that the 4th square from the corner is listed first. (The circled 7's in pattern K represent row 7, column A of pattern M.)

Pattern M also shows all the possible orientations of the basic 12 solutions. Column E, for example, is the A pattern as it would be seen by rotating the board 90° clockwise. Figure P shows the orientation of each of the columns, together with the way it can be obtained from the pattern of column A numerically.

Notice that row 10 of pattern M has only four unique permutations, due to symmetry.

The entire pattern of Figure K is made up of the following entries from Figure M: 1C; 2E; 3D; 4F; 5G; 6H; 7A; 8A; 9E; 10G; 11F; 12B. There is reason to believe that pattern K shows the 12 solutions on one board with the least possible crowding. "Least possible crowding" is defined as that arrangment for which the sum of the cubes of the number of queens on each square is the least. For pattern K, this sum of cubes is 396. Stephen Lieman has shown that the theoretical minimum for this sum of cubes is 360.

Pattern K has 6 blank squares; 26 squares with one queen; 26 squares with two queens; and 6 squares with three queens. The pattern was used for the cover design of the book <u>Problems for Computer Solution</u>, Gruenberger and Jaffray, Wiley, 1965.

POPULAR COMPUTING is published monthly at Box 272, Calabasas, California 91302. Subscription rate in the United States is $15 per year, or $12 if remittance accompanies the order. For all foreign subscriptions, add $5 per year. Multiple subscriptions to the same address, add $5 each; thus, 3 copies per month is $25 per year, U.S. delivery. Back issues $1.50 each. Subscriptions may begin with any issue. Subscriptions for qualified undergraduate students half price.

This "least crowding" problem involves picking one set from each row of pattern M. There are

$$8^{11} \times 4 = 34359738368$$

ways to thread the pattern (there are only four possibilities at row 10). The scheme of attack used was as follows:

Two sets were arbitrarily selected from rows 1 and 2. These two sets were applied to a chessboard, and the resulting pattern was replicated in storage 8 times. Every set from row 3 was then added to these patterns, one set per pattern. The sum of cubes was calculated for the 8 patterns, and the one with the smallest sum was selected. That pattern was then replicated 8 times, and the 8 sets of row 4 were added, and the process was repeated, through row 12. This entire procedure was repeated for each possible choice of two sets from rows 1 and 2 (64 such starting choices) and pattern K is the best result obtained. The effectiveness of the attack depends heavily on the ordering of the rows of Figure M, since we are taking a crude sample of the 34 billion possible choices.

Lieman claims that it is possible to improve the situation, and achieve a pattern for which the sum of cubes will be less than 396. This, then, is the problem: find an arrangement for the 12 solutions to the 8 queens problem that will crowd the board less than pattern K.

PATTERN M

	A	B	C	D	E	F	G	H
1	41582736	63728514	25713864	46831752	74286135	53168247	58417263	36271485
2	41586372	27368514	28613574	47531682	71386425	52468317	58413627	72631485
3	42586137	73168524	62713584	48531726	37286415	51468273	57413862	26831475
4	42736815	51863724	72418536	63581427	27581463	36418572	57263184	48136275
5	42736851	15863724	82417536	63571428	17582463	36428571	57263148	84136275
6	42751863	36815724	52814736	63741825	47185263	36258174	57248136	63184275
7	42857136	63175824	62714853	35841726	37285146	64158273	57142863	36824175
8	42861357	75316824	52617483	38471625	47382516	61528374	57138642	24683175
9	46152837	73825164	35714286	68241753	64285713	31758246	53847162	26174835
10	46827135	53172864	64718253	35281746	35281746	64718253	53172864	46827135
11	47526138	83162574	64713528	82531746	35286471	17468253	52473861	16837425
12	48157263	36275184	36814752	25741863	63185247	74258136	51842736	63724815

8 Queens Figure P

Column	Orientation from Col. A	Derivation numerically from column A
B	Reflect Col. H; that is, view pattern H from underneath.	Reverse the order of the digits in A.
C	Reflect E.	Each digit of C is formed by counting the position number (from the right) of the digits of B, as shown here: Pattern 1B 6 3 7 2 8 5 1 4 Positions numbered from the right 8 7 6 5 4 3 2 1 Form 1C 2 5 7 1 3 8 6 4
D	Pattern A rotated 90° counter-clockwise.	Reverse the order of the digits of C.
E	Pattern A rotated 90° clockwise	Take 9's complement of each digit of C.
F	Reflect D.	Reverse the order of the digits of E.
G	Reflect A.	Take 9's complement of each digit of A.
H	Pattern A rotated 180°	Take 9's complement of each digit of B.

Solution

Timothy Croy furnishes the following solution to Problem 41 (The Cubical Array) and thereby extends his subscription to POPULAR COMPUTING. The APL program shown below solves the problem and prints out the solution.

```
      ∇CUBICAL∆ARRAY[⎕]∇
    ∇ Z←CUBICAL∆ARRAY N
[1]   Z←(3⍴N)⍴⍋⍋+/(¯1+ 100 100 100 ⊤,(10000×⍳N)∘.+(100×⍳N)∘.+⍳N)*2
    ∇
```

Easter

The date of Easter is defined to be the first Sunday after the first Monday after the first full moon after the vernal equinox. The date for any year can be calculated by formulas developed by Gauss (taken from Elementary Number Theory by Uspensky and Heaslet, McGraw-Hill, 1939). The calculations for 1974 will be shown.

Call the year N and its century C (N = 1974 and C = 19 for this year). Calculate

$$M = 15 + C - \left[\frac{C}{4}\right] - \left[\frac{8C + 13}{25}\right]$$

where the brackets denote the greatest integer. For all of the current century, M = 24.

$$L = 4 + C - \left[\frac{C}{4}\right] \bmod 7.$$

Again, in this century, L = 5.

$$\begin{array}{ll} a = N \bmod 4 & (\text{for } 1974,\ a = 2) \\ b = N \bmod 7 & (b = 0) \\ c = N \bmod 19 & (c = 17) \\ d = (19c + M) \bmod 30 & (d = 17) \\ e = (2a + 4b + 6d + L) \bmod 7 & (e = 6) \end{array}$$

Then, with certain exceptions, Easter is either

$$\text{March } (22 + d + e) \quad \text{or} \quad \text{April } (d + e - 9)$$

For 1974, these are March 45 and April 14 (really the same thing).

The exceptions (which occur only in 1954 and 1981 in this century) are these:

If d = 29 and e = 6, Easter is April 19;
If d = 28, e = 6, and M is one of 2, 5, 10, 13, 16, 21, 24, or 29, Easter is April 18.

Easter can thus be as early as March 22 or as late as April 25; neither of these extremes occurs in this century.

Sieves

PROBLEM 43 A-H

The familiar Sieve of Eratosthenes yields prime numbers by the following algorithm:

Write down the consecutive integers from 2 to N. Circle the 2 and cross off every second integer following. Circle the next remaining integer (3) and cross off every third integer following. Continue this process: circle the next remaining integer (K) and cross off every Kth integer following (which will include integers previously crossed off). For the first few integers, the procedure then produces:

2 3 ~~4~~ 5 ~~6~~ 7 ~~8~~ ~~9~~ ~~10~~ 11
~~12~~ 13 ~~14~~ ~~15~~ ~~16~~ 17 ~~18~~ 19 ~~20~~ ~~21~~

The resulting list of (circled) prime numbers is correct to the square of the last K used.

Listed below are some other schemes for sieving the integers. In each case, the Problem is to determine the 1000th circled number.

1. Apply the same scheme as Eratosthenes, but cross off every Kth <u>remaining</u> number. The resulting sequence begins 2, 3, 5, 7, 11, 13, 17, 23, 25, 29, 37,...

2. Apply the scheme of No. 1, but begin the series of integers with 3, rather than 2. The resulting sequence begins 3, 4, 5, 7, 8, 11, 13, 17, 19, 20, 26,...

3. Using the integers from 3 to N, when K is circled, cross off subsequent integers with the value KX+1. For example, when 11 is circled, cross off 12, 23, 34, 45, 56, and so on.

4. Using the integers from 7 to N, when K is circled, cross off subsequent integers with the value KX-1. For example, when 7 is circled, cross off 13, 20, 27, 34, 41, 48, and so on. The resulting sequence begins 7, 8, 9, 10, 11, 12, 14, 16, 18, 22, 25,...

5. Using the integers from 3 to N, when K is circled, cross off every 3rd remaining number. The resulting sequence begins 3, 4, 5, 7, 10, 14, 20, 29,...

6. Using the integers from 3 to N, when K is circled, cross off every Mth remaining number, where M is 2, 4, or 5.

7. Using the integers from 2 to N, circle the 2 and cross off every second number (that is, all even numbers). Circle the first remaining number, 3, and

cross off every third of all remaining numbers (that is, cross off 5, 11, 17, 23, 29, and so on). Circle the first remaining number, 7, and cross off every seventh of all remaining numbers (that is, cross off 19, 39, 61, 81, 103, and so on). Those numbers finally remaining (including 1) form the sequence (1, 2, 3, 7, 9, 13, 15,...) that Ulam named Lucky Numbers.

8. Another of Ulam's sequences is

(1, 2, 3, 4, 6, 8, 11, 13, 16, 18, 26,...)

in which each new member can be formed in one and only one way by adding two different earlier numbers. Thus, numbers like 12 and 15 do not appear because they can be formed in more than one way (8+4, 11+1, for example), and 33 will not appear because it cannot be formed at all.

The original scheme of Eratosthenes for locating prime numbers is not, at first glance, a practical notion, since it seems to say "write down all the numbers in the desired range and then eliminate those that are not prime." Offhand, this corresponds to the advice to young sculptors on how to carve a beautiful statue of a horse: "Take this block of marble and cut away the parts that don't look like a horse." The process suddenly becomes practical with D. H. Lehmer's observation that the numbers themselves are not necessary to the scheme, but only the positions of the numbers, and a computer contains lots of positions; namely, bits. For example, a block of 1000 words (on a 32-bit word machine) can represent 32,000 consecutive numbers. Starting with these bits all set to zero, ones can be stored at every second position after position 2; at every third position after position 3, and so on, following the pattern laid down by Eratosthenes. The bit positions that are still zero after sifting, represent prime numbers. This was the procedure used in 1959 to validate the table of 6,000,000 prime numbers which had been calculated by a less efficient scheme. The entire check calculation took 21 minutes on an IBM 7094, where the original calculation, in 1957, consumed 120 hours on an IBM 704.

For contest purposes (such as the offer to undergraduates made in PC12) these 8 problems are subject to the following rules. (1) At least 4 of the sequences must be explored, and (2) the computer printout should show the first 100 numbers of the sequence, the 1000th number, and the limit on the value of N that was used in the sieve.

BOOK REVIEWS

A THE ELEMENTS OF FORTRAN STYLE
Charles B. Kreitzberg
Ben Schneiderman
Harcourt Brace Jovanovich, 1972, 120 pages.

B THE ELEMENTS OF PROGRAMMING STYLE
Brian Kernighan
P. J. Planger
McGraw-Hill, 1974, 147 pages.

C FORTRAN TECHNIQUES
A. Colin Day
Cambridge University Press, 1972, 96 pages.

Three slim books are now available that all deal with programming style. All three are available in soft cover, 6 x 9 size. Anyone interested in producing better Fortran programs should own all three.

A and B both pay homage to The Elements of Style, W. S. Strunk, Jr., and E. B. White, Macmillan, 1959 (the current version of Strunk's 1919 classic) and point out the parallels between the rules of style in English prose and the need for applying those same rules to the writing of programs.

C is the most straightforward--it deals mostly with ways to perform stock jobs in neat and efficient, if not particularly elegant, Fortran code. Some of the topics covered are: flags and switches; DO-loops in a wide variety of uses; packing and unpacking numbers; number conversions; plotting on line printers; searching and sorting; list processing. C is a no-nonsense compendium of How to Do It.

Books A and B are concerned with style; that is, with programs that are not only correct, but that are easy to read, well documented, efficient, and readily modified. Book A sticks to Fortran; B throws in PL/I. A's emphasis is on the building of program modules; B analyzes longer programs.

Book B, the most recent of the three, is the most dramatic: all of its program examples are taken from standard textbooks. This is a bold idea indeed. Although the authors explain carefully that they do not wish to embarrass anyone, the whole book consists of criticism of programs that have been held out as models to students, in all the best-selling Fortran texts. The

program from the McCracken and Weinberg article in the October 1972 DATAMATION ("How to Write a Readable Fortran Program") is reproduced, together with the letters of comment on it in subsequent issues, and a counter example that the authors found for which the program doesn't even work properly. Since book B displays other authors' codes as bad examples, it should be impeccable itself. Thus, non-ANSI Fortran usage in two of its programs is a weakness.

Book B has little inserted homilies scattered throughout, which contain much condensed wisdom, such as:

Make sure your code "does nothing" gracefully.
Don't diddle code to make it faster--find a better algorithm.
Make it right before you make it faster.
Make it fail-safe before you make it faster.
Make it clear before you make it faster.
Don't comment bad code--rewrite it.
Don't just echo the code with comments--make every comment count.

Book A uses real printouts, reproduced photographically; B uses typesetting for its codes. At one of the few places that A uses typesetting (page 80), two of the exponents are wrong. Book A has some curious references in its bibliography, such as Donn Parker on Ethics and Alan Westin on Privacy. A has an inadequate index; B has an excellent index.

In book B, the authors explain why their improvements to textbook codes really improve things. For example, in completely revamping a code for calendar manipulation, they conclude:

"We have reduced the fifteen internal labels to one, and the 26 GOTOs to two. Since a branch can occur only to a label, we have that much less to worry about." There follows a sensible rule on GOTOs: Use GOTOs only to implement a fundamental structure.

Among other criticisms of the codes used as bad examples, B notes obvious typos in the texts. This may seem like dirty pool (few books--and this may include book B, although none were found--are completely free of typos). The justification is given, on page 32:

"...regrettably, a program with a typo in it won't work. If you're lucky, it will fail to compile. Worse, like this one, it may run but provide subtly wrong answers."

These books deal with the niceties of style in programming. Book A has exactly one flowchart, which contains a decision box containing the phrase "All Equal" with its exits labelled "yes" and "no." Professor Strunk would probably have insisted that an English question end with a question mark. It's a nitpicking matter, but in a book that harps on style, it would be well for the authors to get their style above criticism.

All three of these books are excellent, and can stand re-reading from time to time by anyone who honestly wants to improve his coding ability. Except for book C, the choice of language is immaterial; the principles of writing good code cut across all languages.

Credibility Game

Associate Editor David Babcock furnishes the following statistics on 10,000 plays of the Credibility Game (PC10, Problem 33).

MOVES	FREQ	MOVES	FREQ	MOVES	FREQ	MOVES	FREQ
8	1	21	327	34	83	47	24
9	87	22	301	35	75	48	21
10	373	23	277	36	70	49	9
11	752	24	245	37	57	50	13
12	843	25	238	38	46	51	17
13	887	26	210	39	41	52	16
14	760	27	149	40	48	53	10
15	702	28	159	41	42	54	6
16	572	29	124	42	41	55	8
17	551	30	134	43	46	56	10
18	419	31	125	44	34	57	5
19	392	32	107	45	23	58	5
20	350	33	92	46	16	59	6

The longest game ran 95 moves. The 51 games missing from the table had 6 or less moves each.

ABOVE
ACUTE
ADAPT
ADEPT
ADOPT
ADULT
AFTER
AGONY
AGREE
ALBUM
ALIVE
ALONE
ALOOF
ANISE
ASHEN
BAKER
BEAST
BENCH
BIRTH
BLACK
BLAME
BLEND
BLOWN
BOAST
BOUGH
BOUND
BRAIN
BRASH
BRAWN
BREAD
BRING
BROOD
BROWN
BRUSK
BRUTE
CANDY
CAPER
CAULK
CHAMP
CHAOS
CHECK
CHIDE
CHILD
CHOIR
CHORE
CHOSE
CIDER
CITED
CIVIL
CLASS
CLEAN
CLEAR
CLIMB
CLIME
CLING
CLOSE
CLOVE
CODER
COLOR
COMIC

CORPS	EVENT	HOVER	LIVER	PAPER	RULER
COVET	EVERY	ICONS	LOOSE	PARTY	RUSTY
CRAFT	FAULT	IDEAL	LOSER	PHOTO	SHAFT
CRANE	FEAST	IMAGE	LOYAL	PLAID	SHAKE
CREED	FIELD	INCUR	LUCID	PLATE	SHALL
CRIMP	FIFTH	INEPT	LURID	PLEAD	SHARE
CRISP	FIGHT	INGOT	MANIC	PLUCK	SHELF
CROCK	FINAL	INDEX	MATCH	PRIDE	SHIFT
CROON	FRAME	INNER	MERRY	PRINT	SHORE
CROSS	FROST	INPUT	MIGHT	PROOF	SIGHT
CRUDE	FRUIT	IRATE	MINER	PYLON	SIXTH
DANCE	FUDGE	ISSUE	MISTY	QUEEN	STACK
DEBIT	GLOOM	IVORY	MOTOR	QUEER	STAIN
DEBUG	GLOVE	JAUNT	MUSIC	QUEST	STAKE
DEIGN	GNOME	JEWEL	NADIR	QUEUE	STALK

In this game, each of two players starts with a 5 x 5 array of squares. The players take turns inserting letters into both arrays. Each player must use all letters, and the players do not see each other's array. The object of the game is to build words: horizontally, vertically down, and diagonally northwest to southeast or southwest to northeast. Scoring is done when the arrays are filled. 5-letter words count 10; 4-letter words count 5; 3-letter words count 1. The same word cannot be used twice in a pattern, and plurals count. The strategy of the game calls for a player having some pattern in mind, but to be able to change that pattern to accomodate the letters furnished by the opponent. Erasures are not permitted; each letter must be applied at the time it is called. The theoretical maximum is 120 points. It is fairly easy to produce patterns in the 70's, such as:

RADAR	ICONS	ABOVE
OBESE	DOUBT	NYLON
UMBRA	ELITE	INGOT
GRAND	ABOVE	SUGAR
HEAVY	LOYAL	EMPTY

Guggenheim

PROBLEM 44

Problem: given a supply of 5-letter words, to select them in groups of 5 to form suitable patterns. Write a program to select words from the list given here, to achieve patterns of more than 80 points.

DRAIN	GOOSE	JOINT	NAVAL	QUICK	STALL
DREAM	GRAND	JOULE	NEVER	RABID	STAMP
DRINK	GRATE	JUDGE	NIGHT	RADAR	STAND
DROSS	GREAT	JUICE	NINTH	RANGE	STEAL
EAGLE	GREEN	JUMBO	NOOSE	RAPID	STEAM
EARTH	GRIPE	KINGS	NORTH	RAZOR	STEEL
EBONY	GROWL	KITTY	NOVEL	READY	STICK
EIGHT	GRIME	KNACK	NYLON	REIGN	STILL
ELDER	GRUNT	KNAVE	OBESE	REPLY	STING
ELITE	GUSTY	KNEAD	OLIVE	RIGHT	SLIDE
EMERY	HATCH	KNIFE	ORBIT	ROAST	SLIME
EMPTY	HASTY	KNOCK	ORDER	ROSIN	SLING
ENTER	HAVEN	KRAFT	ORGAN	ROTOR	SMILE
ENTRY	HEART	LATCH	OTTER	ROUGH	SOUND
ENVOY	HEAVY	LIGHT	OUGHT	ROUND	SOUTH

SPORT
SQUIB
SQUID
STOCK
STRIP
STUCK
SUGAR
TABLE
TACIT
TAINT
TENTH
TEPID
TIMER
TIMID
THEME
THING
THIRD
THREW
THROW
TOAST
TOTAL
TRACE
TRACK
TRADE
TRAIL
TRAIT
TRAMP
TREND
TRIAL
TRICK
TRITE
TREAD
TRUMP
UDDER
UMBRA
UNCLE
UNDER
UNTIL
UPPER
VALUE
VALVE
VAPID
VAPOR
VIGOR
VITAL
WEIRD
WHILE
WORRY
WORST
WOULD
WOUND
WRING
WRITE
WRONG
YEARN
YEAST
YIELD
YOUNG
YOUTH
ZEBRA

3X+1 Strings

Various aspects of the 3X+1 Problem have been discussed (PC1-1 and PC4-6). In this problem, take a positive integer, N, let X equal N, and follow the algorithm:

> Replace X by X/2 if X is even.
> Replace X by 3X+1 if X is odd.
> Stop when X equals 1.
> Call the number of terms so generated A, counting the original number.

It has been noted that consecutive values of N can converge with the same A value. For example, the numbers 98 through 102 all have an A value of 26; the numbers 943 through 949 all have an A value of 37, and so on. The calculations for the numbers 98 through 102 are shown here:

98	99	100	101	102 ←	N and initial X
49	298	50	304	51	
148	149	25	152	154	
74	448	76 ←	76	77	
37	224	38		232	
112 ←	112	19		116	
56		58 ←		58	
28		29			
14		88			
7		44			
22 ←		22			
11					
34					
17					
52					
26					
13					
40					
20					
10					
5					
16					
8					
4					
2					
1					

For the numbers 99 through 102, it is not necessary to continue the calculation, since convergence with 26 terms can be seen.

This string phenomenon appears to hold true at any level. For example, the numbers from 996000315 through 996000323 all converge in 256 terms. The largest known

string is of length 40, as given in the table below.

A sub-problem involved within the 3X+1 String Problem is this: What is the logic of detecting and counting the strings, as successive A's are produced? That is, given a program that tests successive values of N for convergence by the 3X+1 algorithm, to note when successive A values are alike and print out the appearance of ever-larger strings. A flowchart for this logic is needed.

In the following table, strings are listed. In each case, the value of N given is the last of the string; for example, the numbers 9089, 9090, 9091, 9092, 9093, 9094, and 9095 all have the same number of terms to convergence. These are not the first appearances of strings of the stated length in all cases.

String length	Final N	String length	Final N
3	9006	18	137169
4	9037	19	447262
5	9062	20	454461
6	9077	21	152216
7	9095	22	212181
8	9463	23	362520
9	1688	24	221208
10	240763	25	57370
11	358042	26	393242
12	131917	27	252574
13	132429	29	331806
14	3000	30	524318
15	134270	32	913350
16	243839	35	1032909
17	7099	40	596349

Overview of Computer Graphic Films

JOHN G. SCOTT

In viewing computer graphics from an artistic, rather than a technological, standpoint, it is possible to overlook some impressive examples of computing. For example, Computer Image Corporation has developed a marvelous method for manipulating prepared imagery, but has yet to produce a film anywhere near the beauty of some of Hy Hirsh's decade-old films. ENERI and DIVERTISSEMENT ROCOCO utilize very simple oscilloscope patterns, but are impressive, nonetheless.

Indeed, abstract and collage film artists are way ahead of their colleagues who work with computers, if only for Jordan Belson's ALLURES, the many films by the late Oskar Fischinger (ALLEGRETTO, MOTION PAINTING, etc.) and the optical printer masterpiece by Pat O'Neill, RUNS GOOD.

Lillian Schwartz and Ken Knowlton are the most advanced, visually, of the computer film makers. ENIGMA is a glorious, multi-layered color experience, while GOOGOLPLEX is their best in black and white. Fast paced and well edited, ENIGMA could only be improved with a more lyrical sound track.

Doris Chase's CIRCLES, CIRCLES/VARIATION 2, and SQUARES, leave much to be desired. These are computer films for people who detest computer films, appealing only to those who enjoy music in elevators and stores, which is produced by people who hate music.

CIBERNETIK 5.3 by John Stehura, is visually very interesting in that it combines live action photography with computer generated designs, but it is not well structured.

John and James Whitney have been the recognized leaders in this field for many years and their offspring, Michael and John, Jr. seem capable of joining them. James Whitney's LAPIS and YANTRA both rely to some degree on hand animation techniques (YANTRA also is hand solarized), so they are not as hard-edged as other computer films. YANTRA lacks a good score, but both films are quite intricate and very lovely.

John Whitney's EXPERIMENTS IN MOTION GRAPHICS demonstrates visually, and through lucid narration (by Whitney) many of the techniques involved in producing computer films. His PERMUATIIONS delightfully introduces many different types of patterns, then proceeds to combine them effortlessly, one atop the next. It is his MATRIX which is the finest film, however, because of the combination of motion picture technique (color saturation and editing) and the excellent graphic design. A perfect sound track adds to its beauty.

The finest work appears to result when the film artist utilizes the computer as a tool with which to produce a film rather than as an end in itself--which is as it should be.

All films except GOOGOLPLEX are available from either

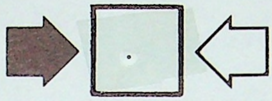
Creative Film Society
7237 Canby
Reseda, CA 91335

or

Pyramid Films
Box 1048
Santa Monica, CA 90401

Magnetic Cores

Attached to each copy of the initial press run of this issue of POPULAR COMPUTING is one or more 20-mil magnetic cores



Although the use of magnetic cores for computer storage is on the way out, it is still the most-used medium. The cores included here are relatively large; they are made as small as 14 mil (.014 inch outside diameter).

N-Series

Log 13 1.11394335230683676920650515794232843082972918838706827180119097499755309163019424080764745425889966

Ln 13 2.56494935746153673605348744156531860480526794476020711641904551066346466732441017939957466344048949

$\sqrt{13}$ 3.605551275463989293119221267470495946251296573845246212710453056227166948293010445204619082018490722

$\sqrt[3]{13}$ 2.351334687720757489500016339956914526915841983462175105040254311588342680996566849807911604202844066

$\sqrt[5]{13}$ 1.67027765233481039480365289131271463129106884569000

$\sqrt[7]{13}$ 1.44256291944297773087944076574194974094230033675150

$\sqrt[10]{13}$ 1.29239222078083184151091319885668716062106296467280

$\sqrt[100]{13}$ 1.02598127241443401135832022443255473090323947603510

e^{13} 442413.392008920503326102775949088281784391306060589715572359330709021862336438212280452273130500

π^{13} 2903677.270613283404988596199487803130470471865942909613299987201766754862018047802519797103400

$\tan^{-1}$ 13 1.494024435525118580001999558492365933991973502511080786182045151464507085324936051532143147989119150

13^{100} 247933511096597253351107288473486513623877446787494114981218909940615869983797556015828566293998218019 2171594001

13^{1000}
877712547297351164963075005029518868335143011009791
587625089497842979736915596129032182962500492014175
841671906680564557971074429054133768011377267004038
686384928365307832441547181678860494588909492578490
088581272498408784373744211192641381824585436261301
805877436870397160492185802311666558635887061294420
939805656260456124885992634433559882281588585109669
822677505315340332078243998767997832128953764564516
376725139675951980560309033269444955337153057161335
231100635005821798250973836208309492064945212335171
736633741024385365911331554758487165547991443921952
015717472913074635105907520740786601257438672606419
699286562714956623804462577907818662434718390591335
771885053705857808493288056970124259866314991127635
712535585079207363553367654125053108675737736996250
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754572359046862785420203445056958162664893406219871
836230342028155588639455813740815945310339591878362
571321331435053105131255173302162715308107508014068
060808052973697565878622736225163272500943586654761
359875358470545595541969660928205919103196260416924
2974038517575645939316377801594539335940001